PMT R&D

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FNAL

PMT R&D

- Issues are: making 150000 tubes in 6 years time, their efficiency, and their pressure performance.
- If PMTs can stand higher pressure, the cavern can be taller => more fiducial volume.
- Have had meetings with Photonis and Hamamatsu: no barrier to PMT production except money.

PMT considerations

	10 inch R7081	20 inch R3600
Number (25% cov)	~50000	~14000
QE	25%	20%
CE	~80%	~70%
rise time	4 ns	10 ns
Tube length	30 cm	68 cm
Weight	1150 gm	8000 gm
Vol.	~5 lt	~50 lt
pressure rating	0.7Mpa	0.6Mpa
ϕ coverage/pmt	0.6 deg	1.1 deg
ϕ granularity	1.0 deg	2.1 deg

PMT: further choice

Items	Example 12-inch PMT	R7081 10-inch PMT	R5912 8-inch PMT
Diameter	300 mm	253 mm	202 mm
Effective Area	280 mm min.	220 mm min.	190 mm min.
Tube Length	330 mm	245 mm	220 mm
Dynodes	LF/10-stage	LF/10-stage	LF/10-stage
Applied Voltage	1500 V	1500 V	1500 V
GAIN	1.00E+07	1.00E+07	1.00E+07
T.T.S.(FWHM)	2.8 ns	2.9 ns	2.4 ns
P/V Ratio	2.5	2.5	2.5
Dark Counts	10,000 cps	7,000 cps	4,000 cps

NEW !

HAMAMATSU
HAMAMATSU PHOTONICS K.K. Electron Tube Division

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Developmental Plan for 12 inch PMT

Date : August 6, 2008

2008		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC	2009 JAN	FEB
PMT Design	Simulation Electron Trajectory	Basic Design		Feedback Check											
	Electrode Design			Practical Design											
Material Preparation								Glass Bulbs				Initial conditioning is done during this period.			
								Electrodes							
								Insulating Plates							
Production for Prototypes															
Inspection														Various Tests	
Delivery															Sample Tubes

Some sample tubes would be available in FEB. 2009.

We need 6 months for preparation of mass-production version.

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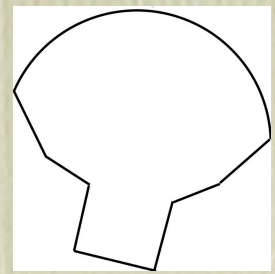
Tube production

Glass

Stamped metal and wire parts

First assembly
vacuum deposition of metal platings
Graded seal

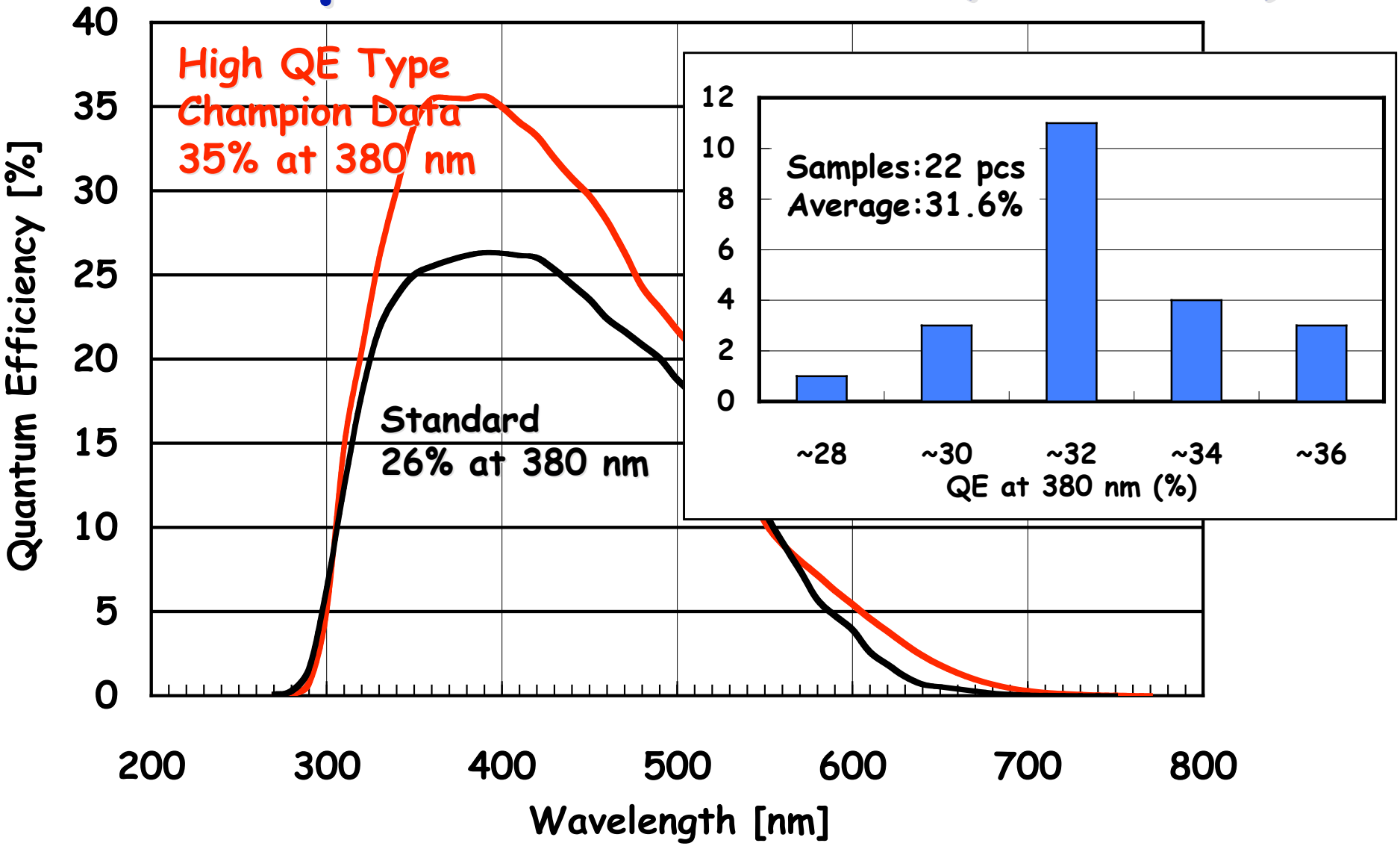


Final vacuum
Cathode deposition

Final assembly of 10 inch tubes needs lab space of 30'x30'; six stations with 6 pmts/station; 1 full day => 36tubes/day = icecube production. tripling this rate is not difficult

HPK and Photonis are NOT concerned about their ability to manufacture at this rate

Example data R7081 (10 inch)



Goal of development is 43%

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Baseline Plan

- The Baseline plan is R7081.
- We will need 50000 to 60000 per chamber depending on shape to obtain similar amount of light collection as SK.
- The correct number to look at is Coverage*QE*Collection eff.
- R7081 has been used by Icecube. There is also production for other projects.
- Only issue for us is pressure performance.

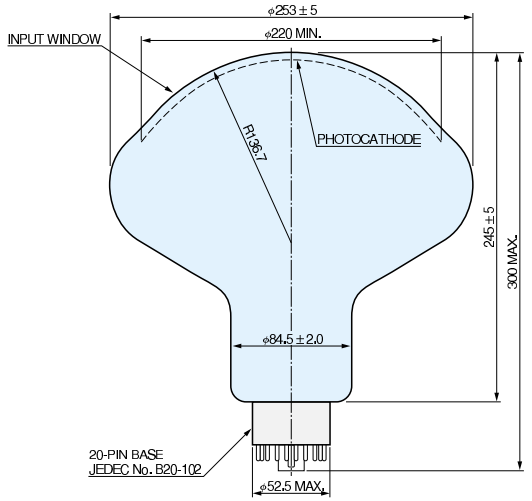
SPECIFICATIONS

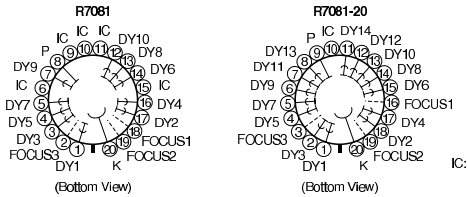
Type No.	Cathode Sensitivity: Luminous (2856 K) Min. (μA/lm)	Cathode Sensitivity: Luminous (2856 K) Typ. (μA/lm)	Cathode Sensitivity: Radiant at 420 nm Typ. (mA/W)	Cathode Sensitivity: Blue Sensitivity Index (CS 5-58) Min.	Cathode Sensitivity: Blue Sensitivity Index (CS 5-58) Typ.	Cathode Sensitivity: Quantum Efficiency at 390 nm Typ. (%)	Anode Sensitivity: Luminous (2856 K) Typ. (A/lm)	Anode Sensitivity: Radiant at 420 nm Typ. (A/W)	Anode Sensitivity: Gain Typ.	Anode Sensitivity: Applied Voltage for Typical Gain Typ. (V)
R5912	40	70	72	6.0	9.0	22	700	7.2×10^5	1.0×10^7	1500
R5912-02	40	70	72	6.0	9.0	22	70 000	7.2×10^7	1.0×10^9	1700
R7081	40	80	80	6.0	10.0	25	800	8.0×10^5	1.0×10^7	1500
R7081-20	40	80	80	6.0	10.0	25	80 000	8.0×10^7	1.0×10^9	1700
R8055	35	60	65	5.5	8.0	20	600	6.5×10^5	1.0×10^7	1500
R3600-02	35	60	65	5.5	8.0	20	600	6.5×10^5	1.0×10^7	2000
R7250	35	60	65	5.5	8.0	20	600	6.5×10^5	1.0×10^7	2000

NOTE: Anode characteristics are measured with the voltage distribution ratio shown below.
( ): Measured with the special voltage distribution ratio (Tapered Divider) shown below.

Type No.	Maximum Ratings: Supply Voltage: Anode to Cathode (V)	Supply Voltage: Anode to Last Dynode (V)	Average Anode Current (mA)	Operating Ambient Temperature (°C)	Storage Temperature (°C)	Pressure (MPa)	Direct Interelectrode Capacitances: Anode to Last Dynode (pF)	Direct Interelectrode Capacitances: Anode to All Other Dynodes (pF)
R5912	2000	300	0.1	-30 to +50	-30 to +50	0.7	approx. 3	approx. 7
R5912-02	2000	300	0.1	-30 to +50	-30 to +50	0.7	approx. 3	approx. 7
R7081	2000	300	0.1	-30 to +50	-30 to +50	0.7	approx. 3	approx. 7
R7081-20	2000	300	0.1	-30 to +50	-30 to +50	0.7	approx. 3	approx. 7
R8055	2500	300	0.1	-30 to +50	-30 to +50	0.15	approx. 10	approx. 20
R3600-02	2500	300	0.1	-30 to +50	-30 to +50	0.6	approx. 36	approx. 40
R7250	2500	300	0.1	-30 to +50	-30 to +50	0.6	approx. 10	approx. 15

●R7081, R7081-20

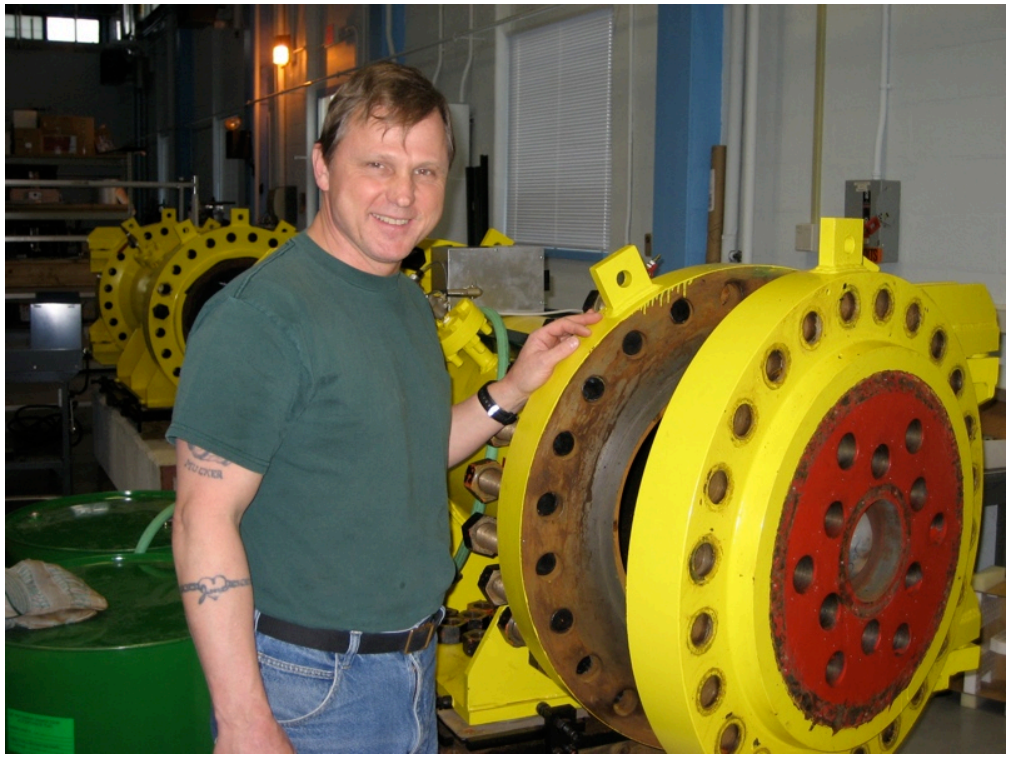


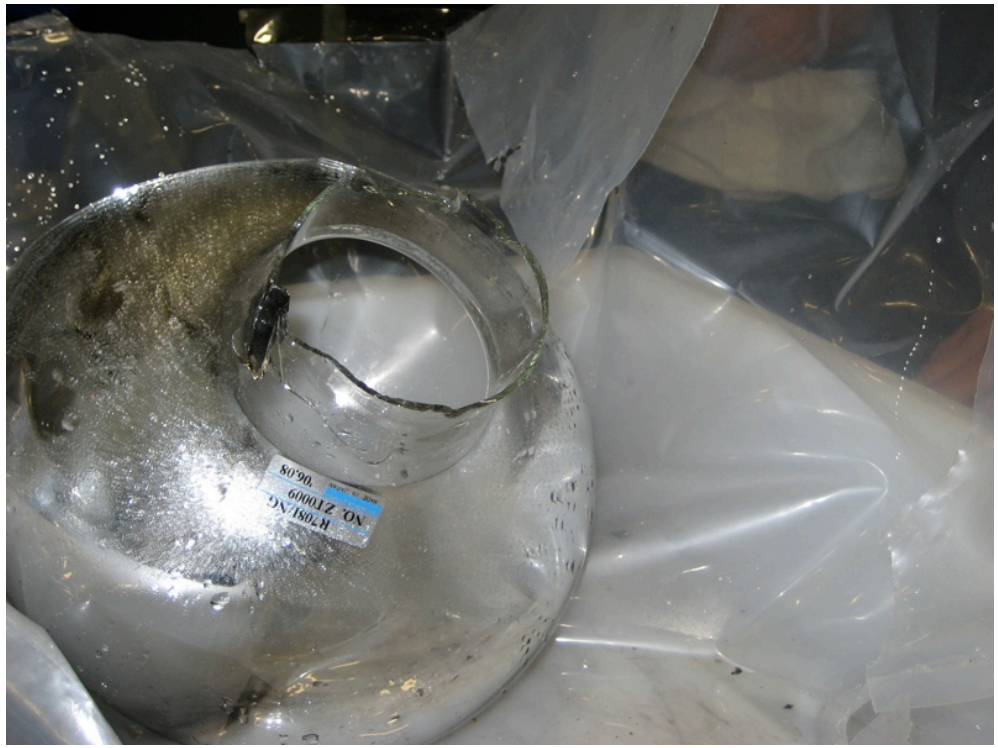


TPMHA0501EA

We are focussed on the R7081 tube
It is more efficient than the R3600.
25% *R7081 => 35% *R3600

Pressure testing





Have 32 phototubes from Hamamatsu. Pressure vessel from BNL. Evolving testing protocol.

Hamamatsu rating is ~7atm. Tested this tube until it broke at 148 psi (~10atm)

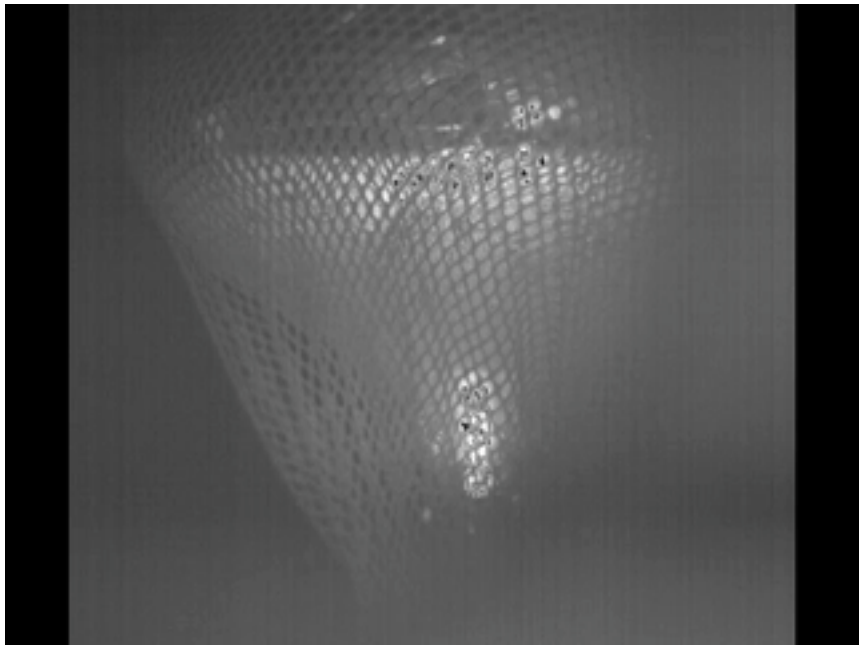
Data so far

PMT	size	Break Press
R7081/ng 1	10inch	148 psi
XP1807 1	12 inch	92 psi
xp18060 1	8 inch	35 psi
R7081 2	10 inch	cycled 132psi
R7081 3	10 inch	cycled 132 psi
R7081 4	10 inch	cycled 132 psi
R7081/lowr1	10 inch	205 psi
R7081/lowr 2	10 inch	218 psi
R7081	10 inch	292 psi
ETL 9350ka	8 inch	68 psi
R7081	10 inch	173 psi

Hamamatsu tested 3 R7081 upto ~10 atm.
One broke at 10 atm,
On each tube, there is data on glass thickness, pressure pulse duration, etc.

What kind of information ?

- Pressure at implosion
- Implosion process. (fast motion movie), photos
- Pressure pulse



↔ 2.5 ms

Breakage at pins

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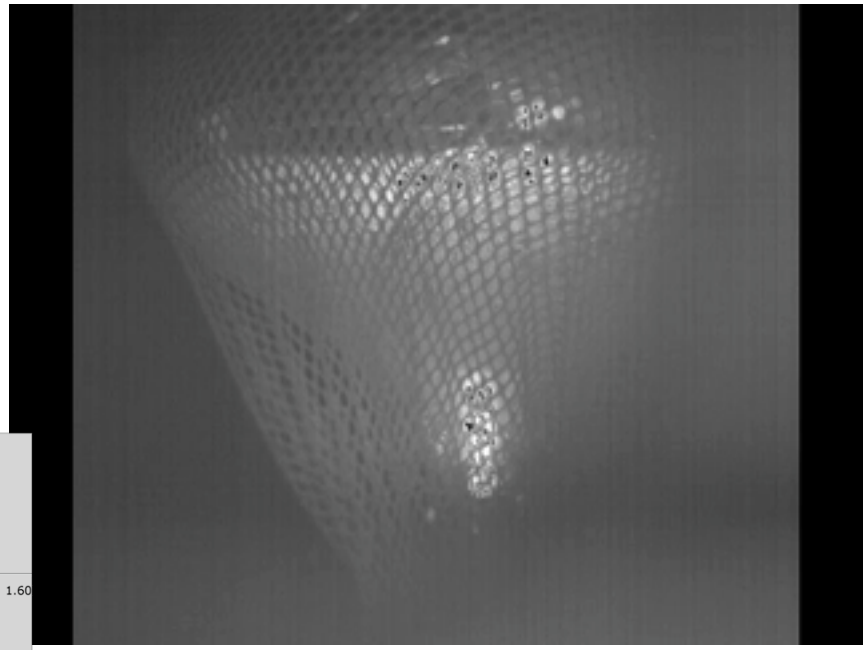

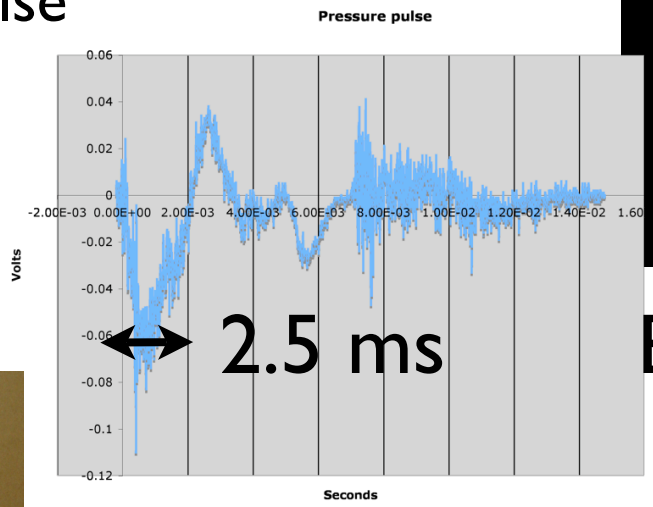

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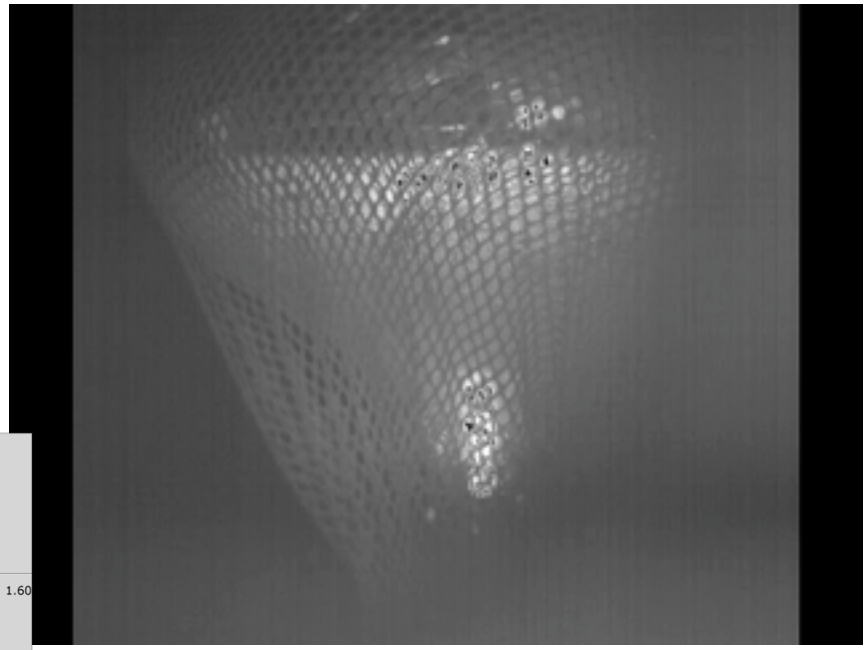

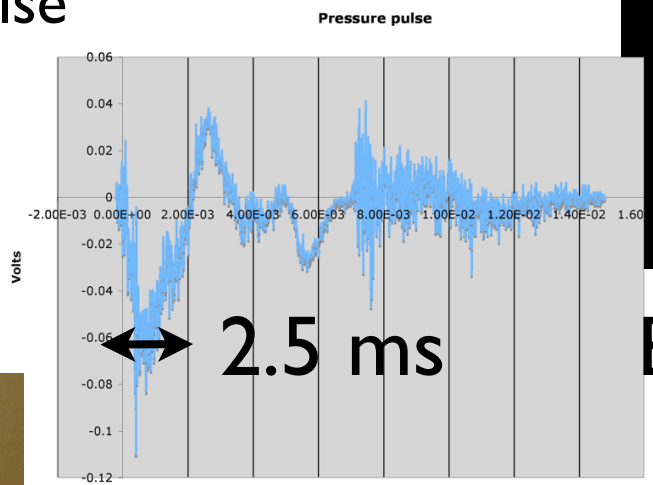

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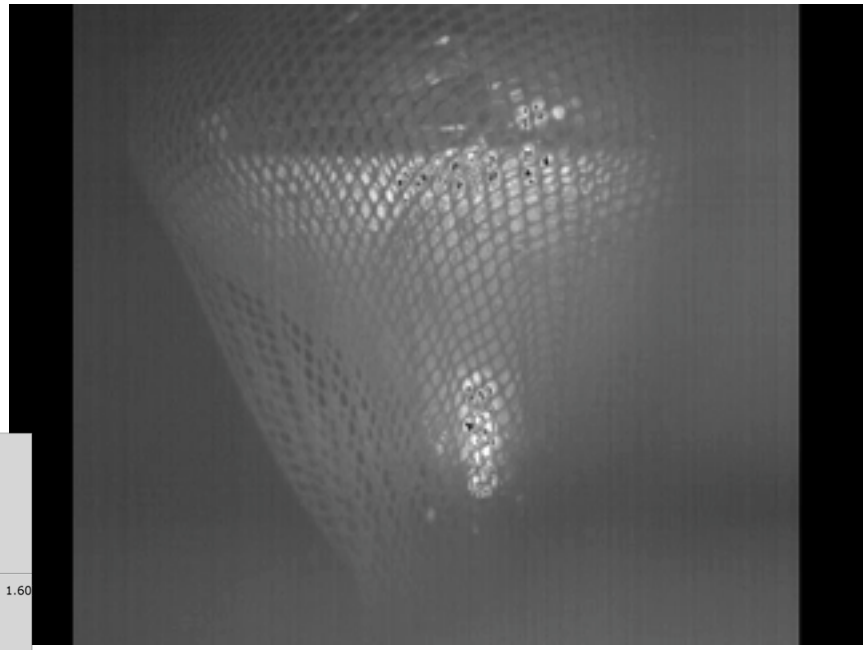

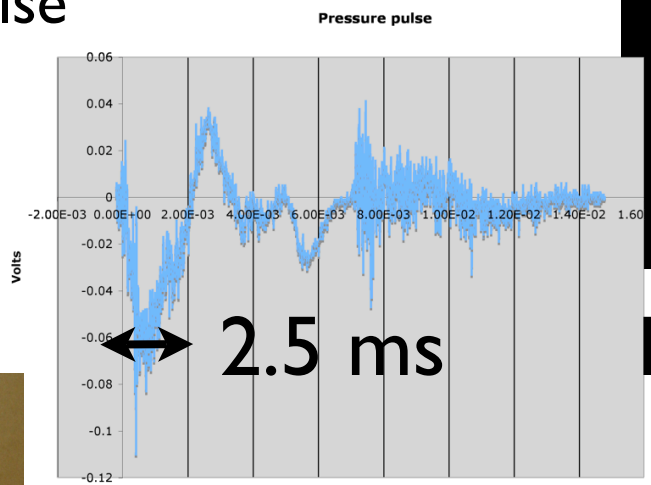

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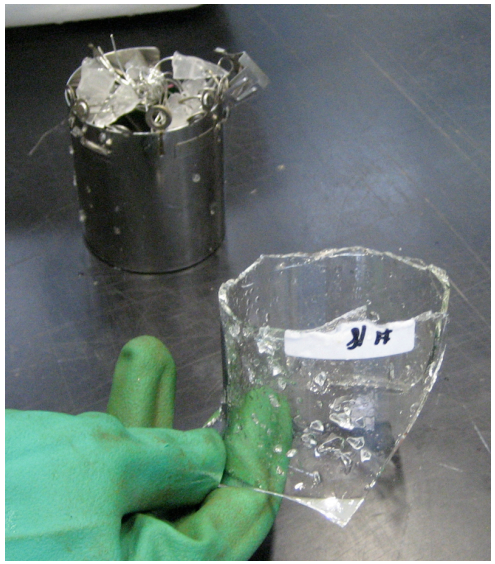
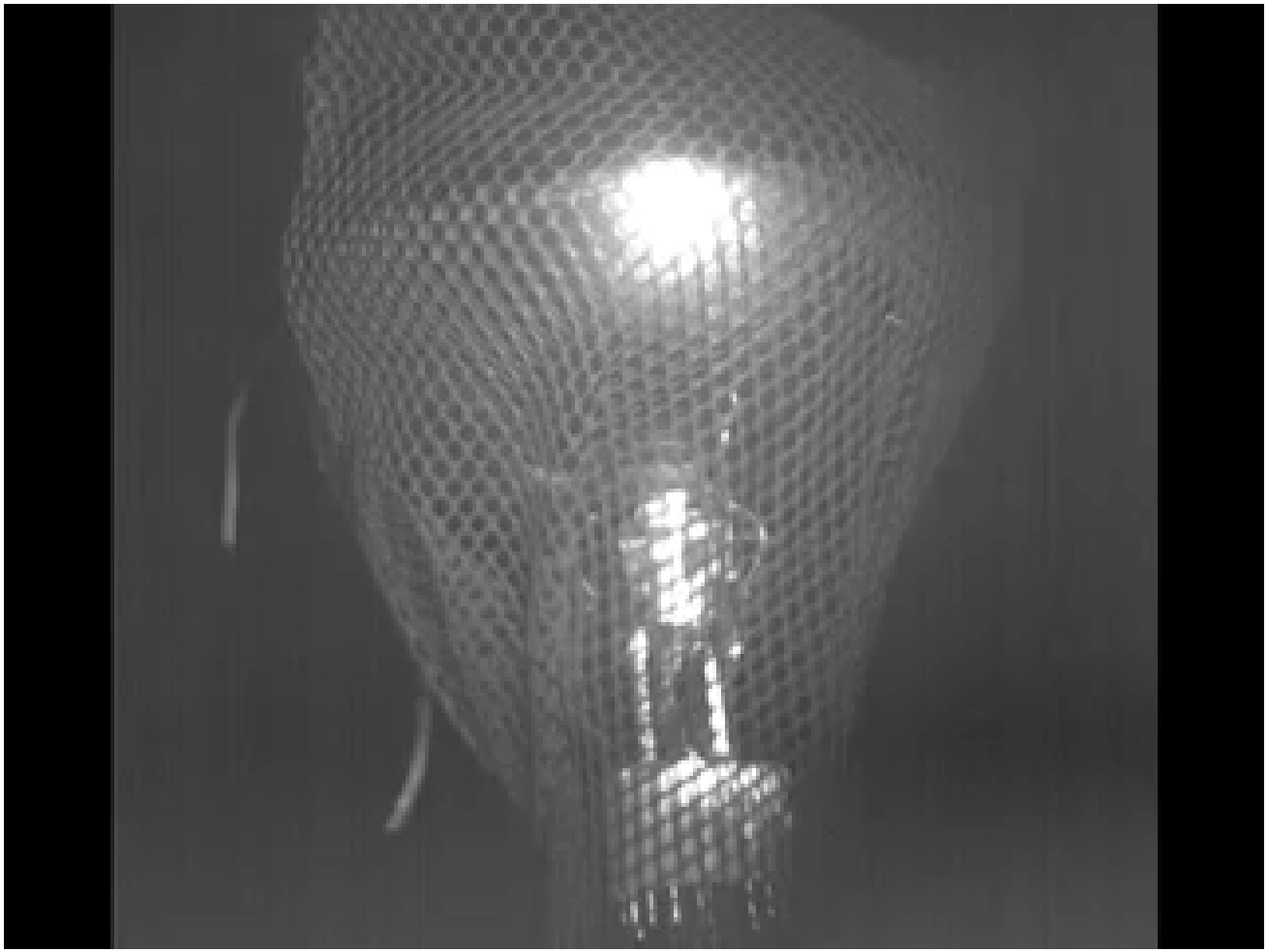
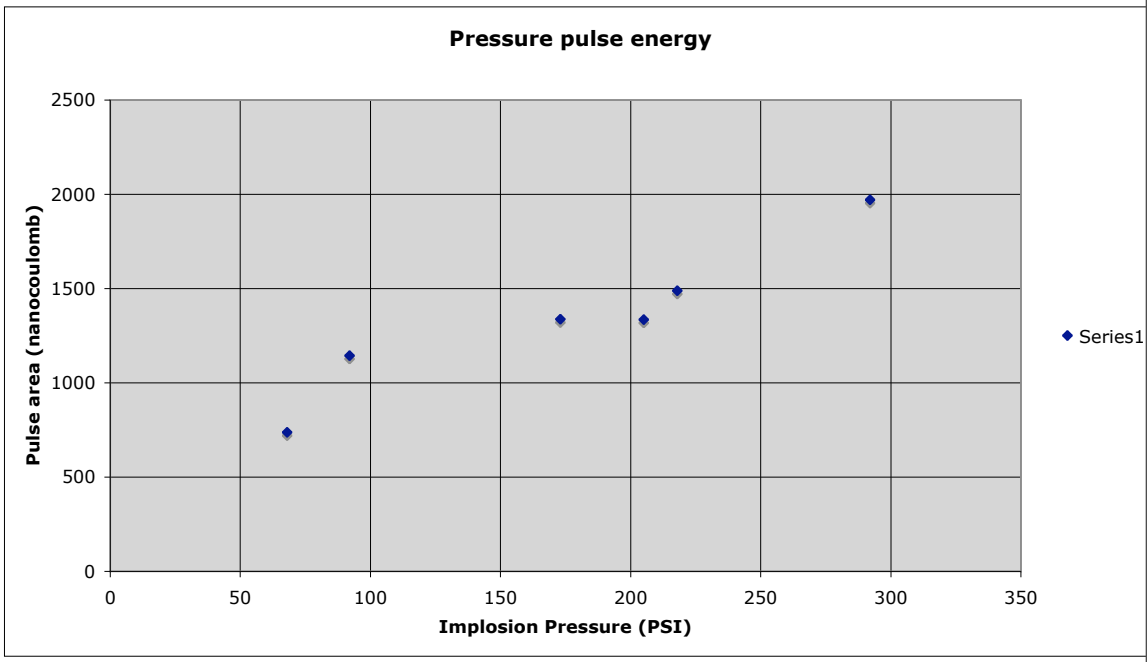


another example



Analysis

- There are 3 modes of failure: pin failure, neck failure and dome failure.
- Pin failure is the best kind because the pressure pulse is spread out in time.
- The total energy in the pulse goes as P*V regardless of failure. It is up to us how to spread it in time.



Summary

- PMT R&D is in progress. There is considerable development in place at BNL, especially on pressure testing.
- Collaboration has started with Orsay. They have received an identical pressure vessel for testing both PMTS and electronics.
- Helpful to have more people involved and other setups.
- So far no funds at BNL in FY2009 for this work (LDRD is finished).
- French have euro 500k grant.